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(21) International Application Number: PCT/SE97/01538 (22) International Filing Date: 11 September 1997 (11.09.97) (30) Priority Data: 9603383-2 17 September 1996 (17.09.96) SE (71) Applicant: TELEFONAKTIEBOLAGET LM ERICSSON (publ) [SE/SE]; S-126 25 Stockholm (SE). (72) Inventors: PALMSKOG, Göran; Stallbacken 13, S-175 43 Järfälla (SE). GUSTAFSSON, Göran; Trumslagaregatan 33, S-582 16 Linköping (SE). HAGEL, Olle, Jonny; Lektorsgatan 3, S-582 35 Linköping (SE). ERIKSEN, Paul; Skogsvägen 16, S-135 45 Tyresö (SE). (74) Agents: BANDELIN, Hans et al.; Telefonaktiebolaget LM Ericsson, Patent and Trademark Dept., S-126 25 Stockholm (SE).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i>
(54) Title: METHOD FOR MANUFACTURING AN OPTOELECTRICAL COMPONENT AND AN OPTOELECTRICAL COMPONENT MANUFACTURED ACCORDING TO THE METHOD (57) Abstract <p>The optoelectrical components which up to now have been used in the fibre-optical region have had waveguides of quartz and glass with hermetic encapsulating, which components have had too high manufacturing costs for profitable use. Through making polymeric single mode (SM) waveguides from plastic, for example, benzocyclobutene polymer (BCB) a simple reliable and inexpensive concept for making waveguides can be obtained. Two of the commercially available grades of BCB/DOW Chemicals have furthermore a refractive index difference which permits manufacturing of buried waveguides with SM characteristics. These two types of BCB material have shown themselves to be especially usable for manufacturing of so-called buried SM waveguides: a heat curable grade (1, 4) used for under- and over-cladding for waveguides and a photo-definable derivative (3) used as the waveguide material. Encapsulating of a waveguide chip can in this way be made with plastics, at the same time as the connector interface can be formed in the end surfaces of the components.</p> <div data-bbox="655 1513 1856 2027"></div>		

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METHOD FOR MANUFACTURING AN OPTOELECTRICAL COMPONENT AND AN OPTOELECTRICAL COMPONENT MANUFACTURED ACCORDING TO THE METHOD

5 FIELD OF THE INVENTION

The present invention relates to a method for manufacturing an optoelectrical component and an optoelectrical component manufactured according to the method, where the optoelectrical component's wave guide can be made of plastic
10 and be enveloped in plastic.

STATE OF THE ART

The introduction of new types of interactive multimedia services has increased the
15 requirement for a substantially increased capacity on existing telecommunication network infrastructures, which is impossible to achieve without a wide use of fibreoptics in connecting, transporting, accessing, and in system equipment. Waveguide technology at a low cost is one of the most important regions which should be able to contribute to the breakthrough for optical solutions. Up to now
20 silicon on silicon generally has been used as a waveguide material in telecommunication applications. A complete accomplishment of a low cost and a large volume scenario, however, requires the introduction of only low cost processes in a few steps, which only could be realized through the use of polymer material.

25 DISCLOSURE OF THE INVENTION

Up to now optical components with waveguides made of plastic have not been able to achieve the highly demanding specifications which have, for example, been required for access components with waveguides made of quartz and glass. Optical

components, both passive and active, would have a large influence on the development of access and data communication applications if they were not so expensive to manufacture. The optoelectrical components which at present have been commercialized within the fibreoptic region have been based on waveguides
5 of quartz and crystal with hermetic encapsulating, which has often given too high costs for volume production.

Through making polymeric single mode (SM) waveguides of benzo cyclobutene polymer (BCB) it is possible to obtain a simple, reliable and inexpensive concept
10 for making waveguides. Two of the commercially available grades of BCB have furthermore a refractive index difference which permits the manufacturing of buried waveguides with SM characteristics. The now commercially available material BCB exists under the name of CycloteneTM, which is a relatively new material from Dow Chemical and in the first instance was developed and intended
15 for dielectric layers in microelectronic applications. The BCB material has extremely good dielectric characteristics, low moisture absorption, better planarisation characteristics, better thermostability and lower shrinkage compared with polyimides. Two types of BCB material have especially shown themselves to be usable for the manufacturing of buried SM waveguides. A heat curing grade is
20 used for the under and over cladding of waveguides, and a photo definable derivative called photo BCB is used as waveguide material. Encapsulating of a waveguide chip can in this way be made with plastic, at the same time as the connector interface could be formed in the end surfaces of the components.

25 With this waveguide concept it is possible to achieve a large development potential for the manufacturing of inexpensive optoelectrical components, where the waveguide can be connected to active components such as PIN and laser diodes in order to, for example, make transceiver modules. Through developing the concept for manufacturing of optical active and passive components with BCB waveguide

technology, a number of difficult steps in the development can be reduced to a manageable number in order to then develop commercially interesting products such as optical splitters and WDM filter modules with MT interfaces at both ends.

- 5 The use of an MT connection interface of the "retainer" type according to the invention makes it possible to obtain low manufacturing cost and larger compactness compared with, for example, so-called pigtail construction

At the same time the new manufacturing technology for large volumes at a low
10 cost must be brought into focus. Therefore, for these purposes, competence must be built up for injector moulding and transfer pressing of small plastic details in large volumes with extremely tight tolerances. The potential reliability problems with, in the first instance, the active components could in this way be solved at a later stage, when the plastic materials process and device compatibility problems
15 would be better known.

DESCRIPTION OF THE FIGURES

- Figure 1 shows simplified a power splitter module according to the invention.
20 Figure 2 shows a part of an E-beam mask for waveguide production.
Figure 3 shows an encapsulated splitter module according to the invention connected with a ribbon fibre connection connector.
Figure 4 shows a damping curve for a BCB waveguide 6 Tm, 3.6 cm long.
Figures 5A and B show an optical evaluation of a directional coupler.

25

DESCRIPTION OF A PREFERRED EMBODIMENT

The method for producing an optoelectrical component according to the invention, i.e. the technology itself of forming it, is based upon the manufacturing of single

mode waveguides from BCB and on the encapsulating of these with a simultaneous passive alignment. The process flow for the manufacturing of an SM-BCB waveguide will be described first here:

- 5 The waveguide structure in a power splitter module according to Figure 1 can consist firstly of a bottom-cladding 1 of a BCB (without antioxidant) on a substrate 2 such as a 1.3 mm thick silicon disc, then a core of a photo patternable BCB (Cyclotene 4024-40) 3 and an over-cladding of a BCB (without antioxidant) 4. The bottom- or under-cladding 1 is applied through spin deposition of BCB without
10 antioxidant XU 13005.19, 1200 rpm, 10 Tm on the silicon disc 2, followed by "soft baking" in a disc oven in a nitrogen gas atmosphere with a special program. The core 3 is made through spin deposition of Cyclotene 4024-40 at 3000 rpm, 5 Tm and then prebaking in a convection oven at a temperature of 90°C for 10 minutes followed by exposure in curing contact with an E-beam manufactured
15 lithographic mask 5, see Figure 2, for forming the waveguide pattern. Developing takes place with DS3000 at a temperature of 30°C for 15 minutes and is followed by rinsing with a soap and water solution. Drying takes place on a spinner or a rinser and dryer. The following soft baking can take place in a disc oven in a nitrogen atmosphere according to a special IMC baking program. The over-
20 cladding 4 takes place through spin deposition of BCB without antioxidant XU 13005.01, at 1200 rpm, 10 Tm followed by a cure baking in a disc oven in a nitrogen gas atmosphere according to a special baking program. The aligning structure 6, like the V-groove structure in the silicon disc of 0.75 Tm, can be patterned with BCB as a mask, at which preferably three masks consequently must
25 be used. During the subsequent component manufacturing a waveguide chip is sawn out of the silicon disc through a suitable standard method, when the disc first then is placed into a tool intended for compression moulding.

The V-grooves of the silicon disc is in this instance adapted so that the pins of the mould for shaping of the holes 7 for the guide pins 8 of the MT connector are pressed against these. In this way the quality technology photo lithographic technique can be used for the alignment of the guide pins of the connector with the waveguides. Respective BCB plastic is used for the waveguides and for the encapsulating of the waveguides and for shaping of the optical interface together with the silicon. The last stage in the manufacturing of components is polishing of the interface 9, silicon and plastic (BCB) together, which can be performed with a conventional polishing technique such as for an MT connector. With an E-beam manufactured lithographic mask 5, see Figure 2, both straight 10, splitter 11 and directional coupler patterns 12 can be produced. Figure 2 shows a part of an E-beam mask 5 with several different patterns. The division between waveguides in the end surfaces can be 250 Tm, whereby the size of the chip should be adapted to, for example, the mould space of a transfer press. The bending radius used in a Y-splitter and a directional coupler can be chosen to be around 30 mm. The directional couplers can have widths of between 6 and 10 Tm and different lengths and separation distances. A typical core layer thickness could be 7 Tm.

A splitter/distributor can then be connected to a connection connector. Both encapsulated and non-encapsulated waveguides have been investigated concerning optical characteristics. The waveguide's SM characteristic has been investigated for different batches of BCB on naked chips, where it has been possible to show suitable reproducibility. A preliminary aging test has also been performed and it has shown that the SM characteristics can be retained for at least one year for non encapsulated waveguides. Attenuation has been measured to be approximately 0.6 dB/cm in "cut back measurements" on a multimode waveguide.

Figure 3 shows an encapsulated direction coupler 13 connected to an optical fibre connection connector, a so-called MT connector 14. A transfer moulding process

is used to encapsulate the waveguide structures and to form an optical MT interface. The material used should be a heat curing plastic containing silicon. In order to arrange the direction of the waveguides in relation to the interface,

V-grooves can be etched on the silicon substrate with a standard process, for example etching with KOH. In the moulding tool these V-grooves are pressed against metal pins and consequently form the precise holes for the MT interface's guide pins. In this case the directional precision depends on the accuracy in the lithographic method for patterning of the waveguides and on the KOH etching for the V grooves which make the mechanical stability of the plastic material less important. This technique has a potential to achieve single mode performance, i.e. around ± 0.5 Tm direction precision. Polishing of the MT interface with BCB waveguides on silicon carriers was performed with a modification of the standard method used for optical connection connectors.

In order to evaluate the so-called BCB waveguides, optical loss measurements were performed on both encapsulated and non-encapsulated straight waveguides while the directional coupler structures were also evaluated optically. The optical losses for different waveguide widths were measured in a spectrum analysis in the wavelength region 0.6-1.6 Tm. The light from a white light source was butt-connected here to the waveguide with the use of a single mode fibre with, for example, an index-adapted gel. At the output the BCB waveguide was connected to a multimode fibre (NA = 0.25) with the use of an index-adapted gel.

Figure 4 shows a diagram for waveguides wherein the in- and output connection losses are added. For straight waveguides with widths up to 12 Tm the single mode performance was determined. A typical curve for the optical losses as a function of wavelengths for a 6 Tm waveguide are shown in the figure. The loss measurements of the encapsulated straight waveguide with polished end surfaces gave almost the same losses as for non-encapsulated waveguides.

Figures 5A and B shows the evaluation of directional coupler structures, whereby the measurements shown together with other measurements show that the developed waveguide concept can well separate wavelengths 1330 and 1550. In the figures only an example of the results from the characterization of the directional couplers is given. The directional couplers have the same reciprocal action lengths but different distances between the waveguides in the connecting region. For each directional coupler, light is transmitted in one of the two input wave-guides. The optical effect was measured from the same channel waveguide, see Figure 5A and from the other waveguide, see Figure 5B. The results are shown as a function of the waveguide separation. In Figures A and B it is shown that the directional connector with a waveguide separation of 5.9 Tm functions like a VDM filter which can differentiate wavelengths of 1.31 Tm and 1.53 Tm in two different output exits. As a conclusion it can be said that through the use of BCB waveguides for optical passive branch arrangements, single mode performance can be achieved with uncomplicated standard methods, waveguides can be used as straight waveguides, power dividers and VDM filters with or without connected active components and can permit plastic encapsulation and standard methods for interface polishing.

CLAIMS

1. Method for producing an optoelectrical component with waveguides connectable for example to a connection connector or the like, characterized by that on a
5 foundation such as a substrate of, for example, silicon a layer of a first material is laid upon which a second material is then laid, when the materials have been chosen in order to cooperate for forming a waveguide, that with, for example, a mask with a suitable waveguide pattern for the component, parts of the second material are removed in order to form a waveguide pattern on the first material,
10 that a further layer of the first material is applied onto the waveguide pattern and the space around the waveguide pattern, whereby the waveguide pattern becomes surrounded by the first material and that the end surfaces of the optoelectrical component are arranged in order to be connectable, for example through grinding and polishing.
- 15
2. Method according to Claim 1, characterized in that as the first material is used benzocyclobutene polymer (BCB) and as the other material is used photo-patternable benzocyclobutene polymer (BCB, Cyclotene 4024-40).
- 20 3. Optoelectrical component with waveguides connectable, for example, to connecting connectors or the like, characterized in that in a foundation (2) of, for example, silicon a layer of a first material (1) is arranged, that on the first material is arranged a waveguide pattern of a second material (3), that on the waveguide pattern and the space around the waveguide pattern is arranged a further layer of
25 the first material (4), wherein the waveguide pattern (3) is surrounded by the first material (1, 4) and that the materials have been chosen in order to cooperate for the forming of the waveguide.

4. Optoelectrical component according to Claim 3, characterized in that at least one active component is connected to a waveguide.
5. Optoelectrical component according to Claim 3 or 4, characterized in that the waveguide pattern comprises at least one splitter (11).
6. Optoelectrical component according to Claim 3 or 4, characterized in that the waveguide pattern comprises at least one directional coupler.
- 10 7. Optoelectrical component according to any of Claims 3-6, characterized in that the first material (1, 4) is benzocyclobutene polymer (BCB) and that the second material (3) is photo-patternable benzocyclobutene polymer (BCB, Cyclotene 4024-40).

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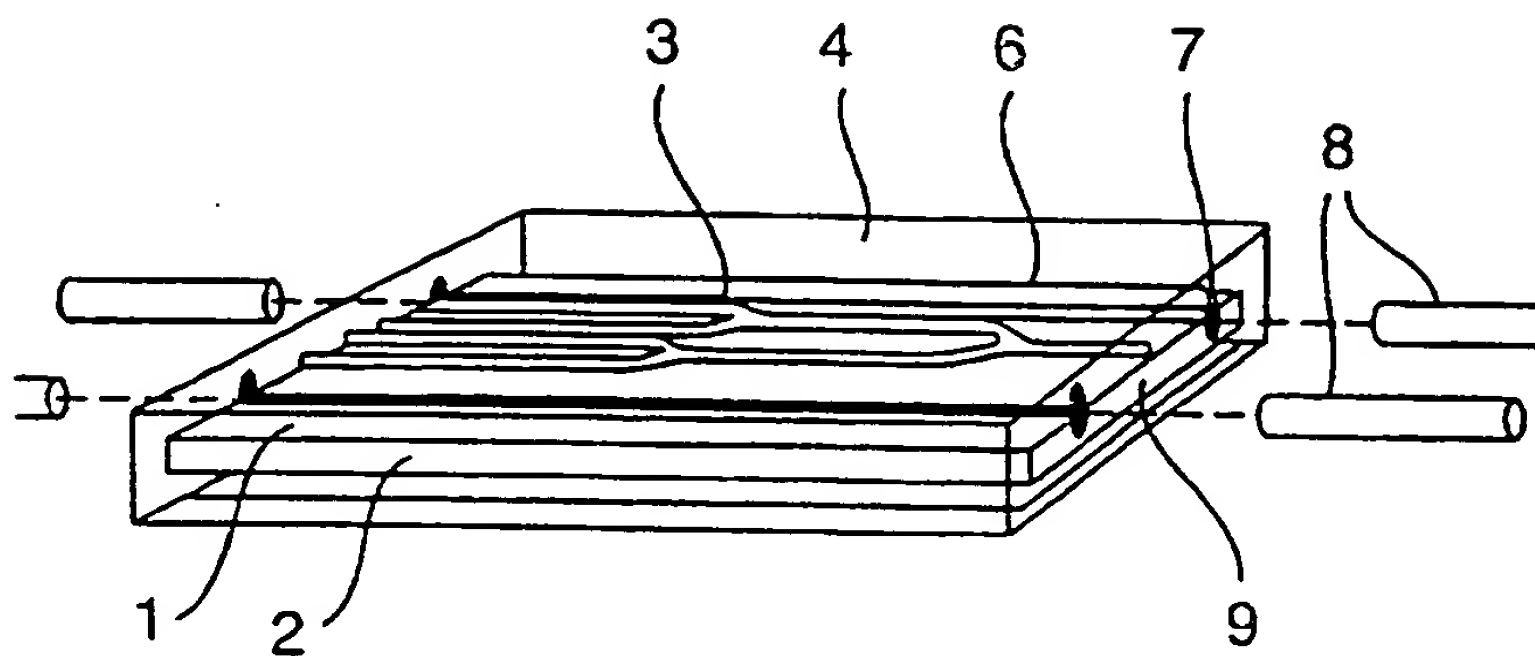


Fig. 1

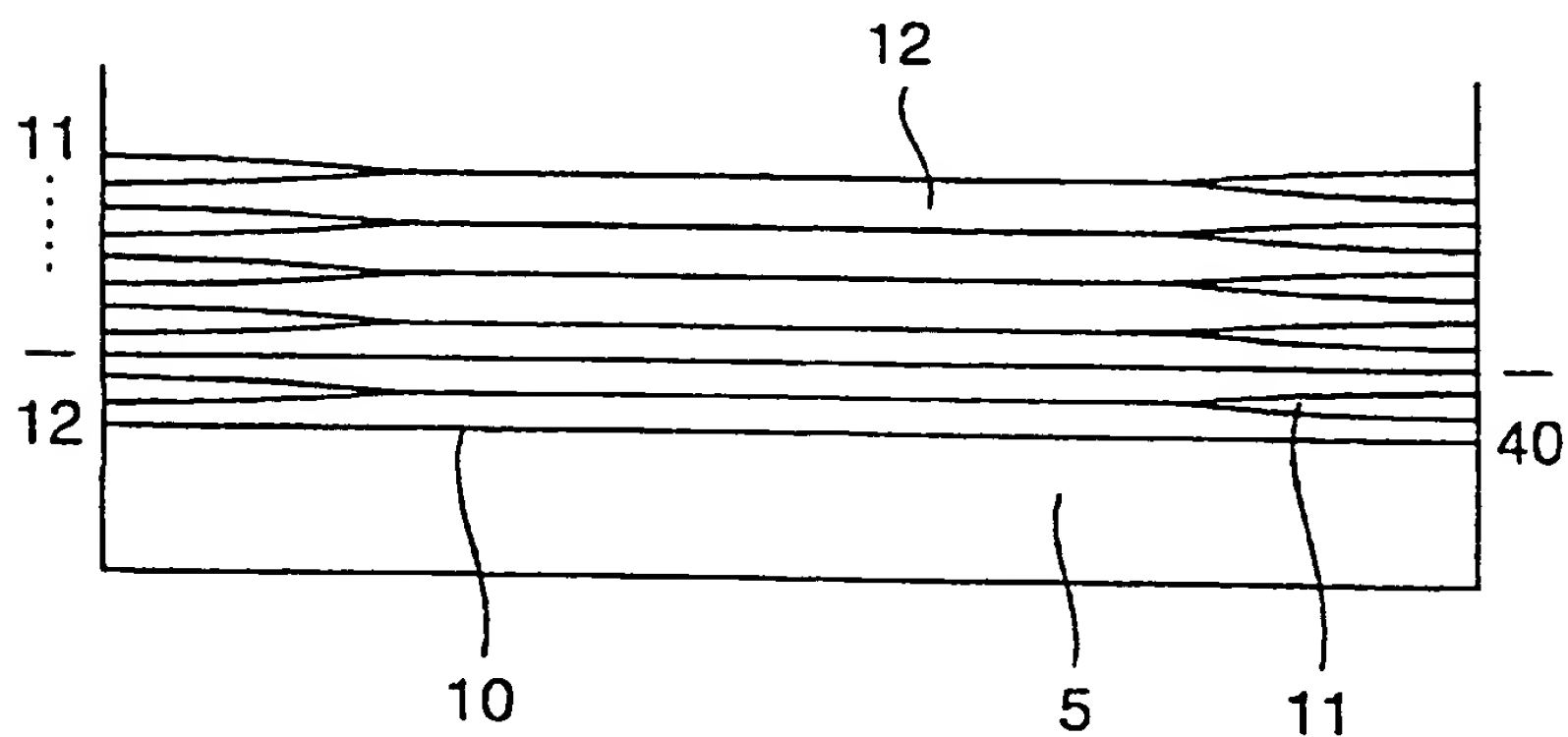


Fig. 2

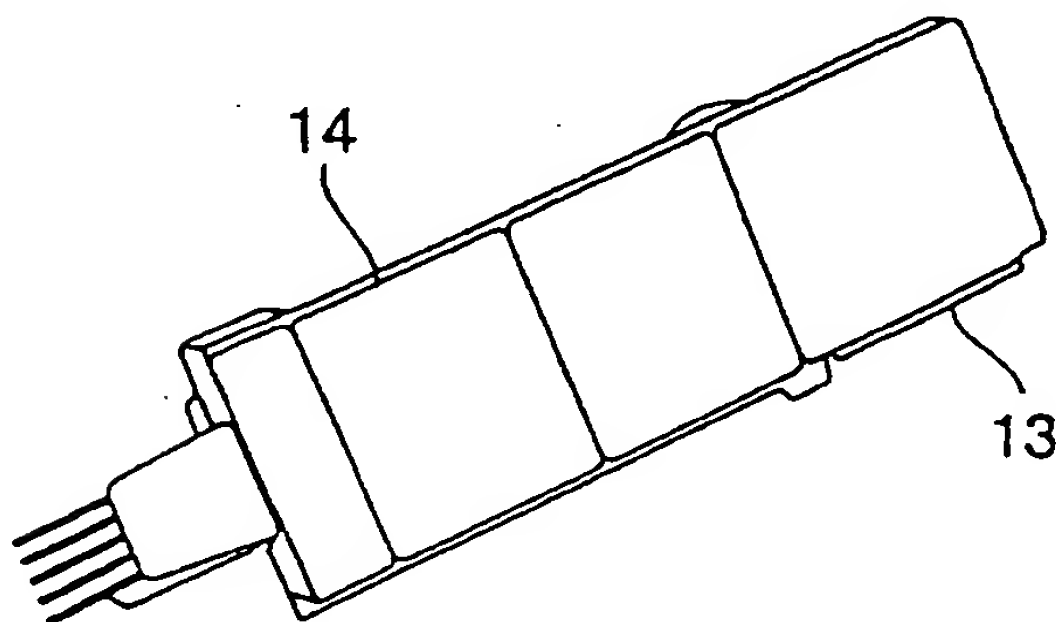


Fig. 3

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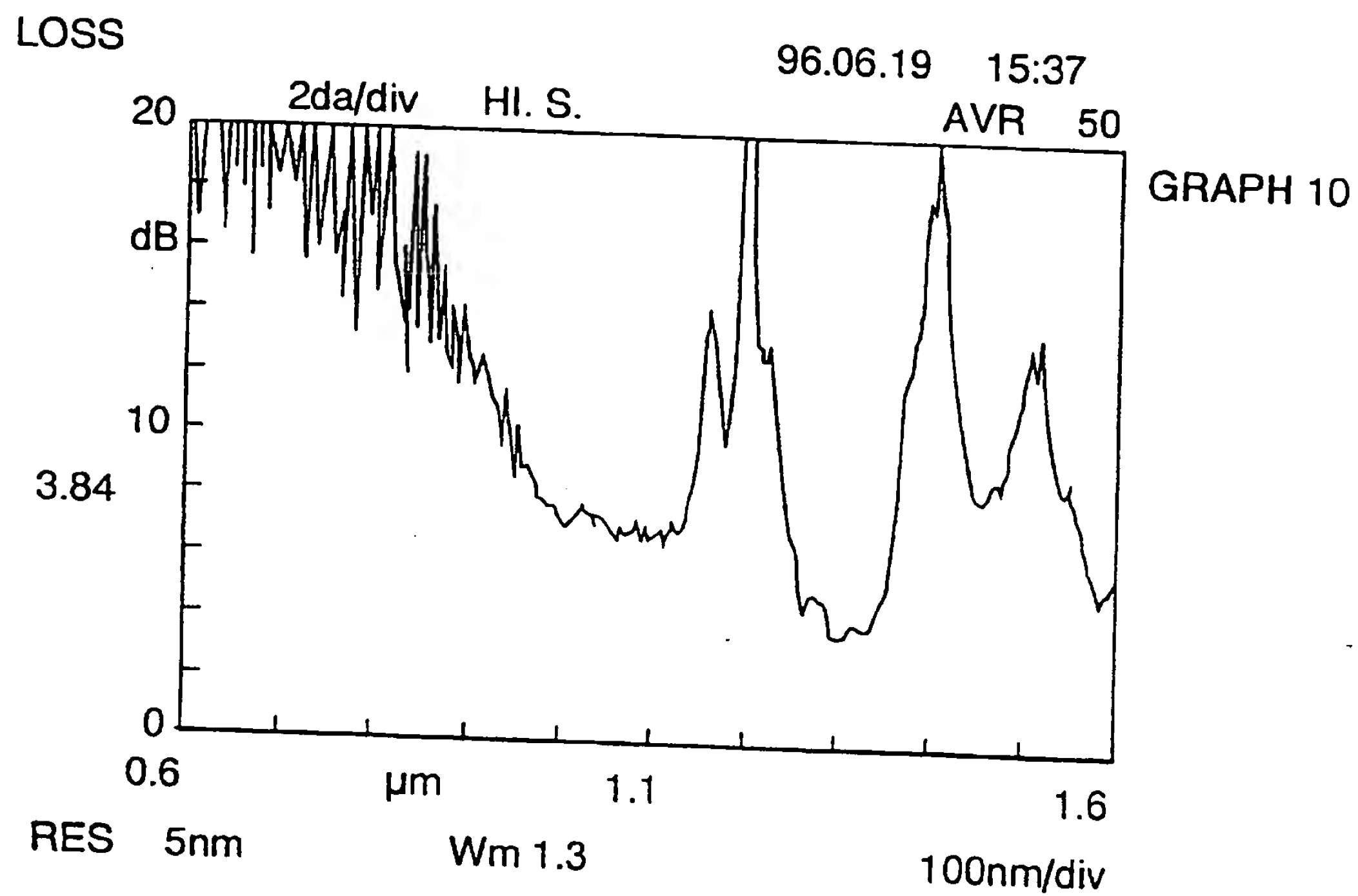


Fig. 4

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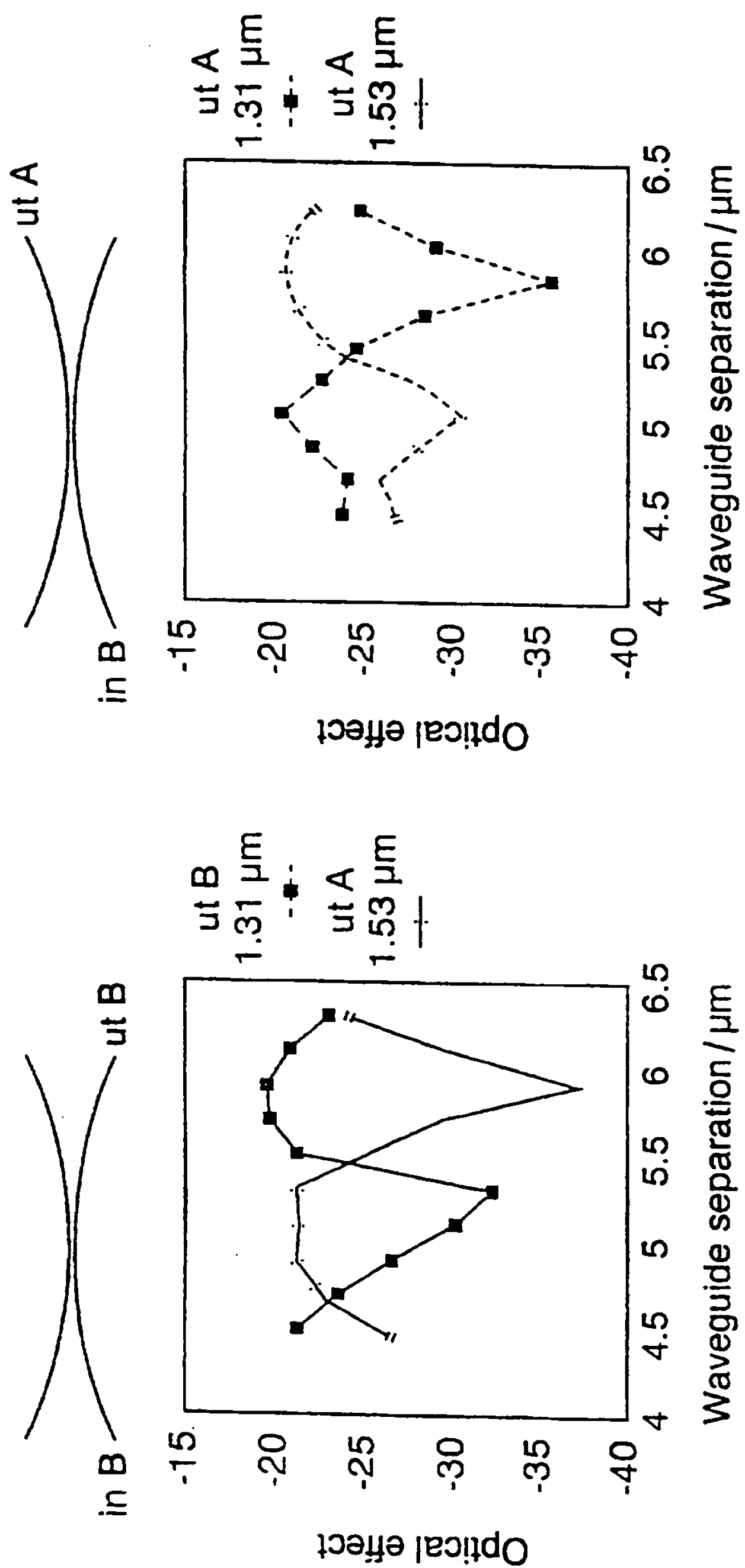


Fig. 5B

Fig. 5A

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/01538

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G02B 6/12

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

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C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5291574 A (REGINE LEVENSON ET AL), 1 March 1994 (01.03.94)	1,3-6
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X	EP 0504882 A2 (FUJITSU LIMITED), 23 Sept 1992 (23.09.92)	1,3-6
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☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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INTERNATIONAL SEARCH REPORT
Information on patent family members

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Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5291574 A	01/03/94	DE 69209982 D,T EP 0544596 A,B FR 2684239 A,B	02/10/96 02/06/93 28/05/93
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